GPS 1547

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Adm.

COMPUTATION
of
HORIZONTAL CONTROL

NAD83 (1993)

NAVD 88

State: KENTUCKY

LOCALITY

KENTUCKY FBN/CBN

.....

Year of Observation, 2002
Year of Computation, 2004

Chief of Party: Gary Means

Observer Several NGS

Computer Gloria G. Edwards

U.S. DEPARTMENT OF COMMERCE
National Oceanic & Atmospheric Administration
National Ocean Service
National Geodetic Survey

REPORT OF HORIZONTAL CONTROL COMPUTATIONS

Observation and Analysis Division
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State Identification: KY-883

Classification: A Order (1:10,000,000)

Horizontal Datum: NAD83 (1993)

Vertical Datum: NAVD 88

Geoid: GEOID03 Ellipsoid: GRS 80

Locality: KENTUCKY FBN/CBN

Acc. No.: GPS1547

Date of Field Work: 2002 Chief of Party: Gary Means

******OFFICE COMPUTATION******

Acc. No.: GPS°1547 Date of Computation: 10/2004

Number of Stations:

New:	= 77	Main Scheme:	= 221
Old:		Supplemental:	=
Fixed:	= 141	Non-monumented:	=
Readjusted:	= 3	Temporary:	
Total	= 221	Total	= 221

Free adjustment variance of unit weight (σ^2_o): = 91.64
Constrained adjustment variance of unit weight (σ^2_1): = 907.10
Ratio: σ^2_1/σ^2_o = 9.80

Gloria G. Edwards
Gloria G. Edwards
Geodesist in charge of work

Vasanthi Kammula
Chief of Branch

Elizabeth B. Wade
Chief of Division

PROJECT DATA

Locality: Kentucky FBN/CBN

Source: GPS1547

Year of Observation: 2002

Sketch No: GPS1547

Number of occupied stations: 221
Number of unoccupied stations: 0

Variance of Unit Weight (free adjustment): 91.64
Degrees of Freedom (free adjustment): 2814

Variance of Unit Weight (constrained adjustment): 907.10
Degrees of Freedom (constrained adjustment): 3111

Variance of Unit Weight (vertical adjustment): 107.84
Degrees of Freedom (vertical adjustment): 2930

Purpose

The Kentucky FBN/CBN project was adjusted to the NAD83 (1993) datum to enhance the existing reference system to provide the accessibility and high accuracy required for use with GPS.

This is an A Order project which consists of two hundred twenty one (221) stations with one thousand one hundred fifty eight (1158) observed vectors.

The following CORS were included in this project. They were computed from the NAD83 (EPOCH 2002.00) transformation from the ITRF00 (EPOCH 1997.0) coordinates:

ASHEVILLE CORS ARP
BECKLEY COOP CORS ARP
BLOOMFIELD CORS ARP
ERLANGER CORS ARP
HARTSVILLE CORS ARP
LOUISVILLE 1 CORS ARP
PIKETON CORS ARP

The accuracy standards requirement for the new stations is 1:10,000,000.

Observation File Analysis

The program *CHKOBS* was run for data verification of the contents in the Blue Book observation file. No major errors were identified by this checking program.

The program *OBSCHK* was run to check the Gfile against the Bfile to verify the consistency of the data that will be loaded in the NGSIDB. No major problems were identified by this checking program.

Description Analysis

All stations in this project have either a description or recovery note, except the CORS which were deleted from the dfile by this office.

Seven other stations do not have descriptions; they were deleted from the final dfile because they were previously incorporated in the NGSIDB. The CORS and the seven stations are listed on the OBSDES printout. The final dfile was converted to the 27 datum.

The programs **CHKDDESC, DESC_POS, DISCREP** and **NEIGHBOR** were run to check the formats of the submitted description file and to compare the recovery notes of stations in this project containing assigned PID codes with the descriptions in the NGSIDB. Coordinates for seventy nine stations were submitted incorrectly. They were investigated and corrected.

The messages generated by the program DISCREP were caused by differences between the NGSIDB and the recent data submitted. The new information in the dfile will be used to update the NGSIDB.

The program **OBSDES** was run to compare the dfile with the blue book file for data consistency. No major errors were identified by this checking program. However, the stations listed on the printout were deleted in the description file.

The NGS program ***GEOID03*** was used to determine a geoid height for each station in the project.

Free Adjustment

A minimally constrained horizontal adjustment was executed. The NAD83 CORS coordinates and ellipsoid height for **HARTSVILLE CORS ARP**, were held. These coordinates were transformed from ITRF00 (EPOCH 1997.0).

This adjustment produced a variance of unit weight of 91.64 with 2814 degrees of freedom. The standard deviation of unit weight was 9.573. Because this is an A Order project, the standard errors of the observations were not scaled in the Gfile.

A residual plot was done on the vectors to determine if there were any outliers. No outliers were found. See Figure 1 for a residual plot of the free adjustment.

A comparison was made between the coordinates of the free adjustment and the published coordinates from the data base to determine the shifts. The largest shift was 0.088 meters at a B order HARN station (**I75 T 52 RM 2**) located in Kentucky, see Attachment 1.

Ellipsoid heights differences of the free adjustment to the published ellipsoid heights are listed on Attachment 2. The 3 decimeter shift at **CINDY AZ MK** was investigated. Gary Means in the Norfolk survey office was notified and he found the problem to be with the antenna height used at this station. The problem was therefore resolved. Figure 2 also shows the ellipsoid height differences.

Constrained Adjustment

A preliminary constrained adjustment was run holding the previously determined A/B Order coordinates and ellipsoid heights of the Kentucky High Accuracy Reference Network (HARN) projects. In addition, the NAD83 CORS coordinates transformed from ITRF00 (EPOCH 1997.0) and coordinates from Illinois, Virginia and West Virginia HARN projects were included. They were rigidly held fixed to prevent shifts in the controls. Attachment 3 lists the control used in this adjustment.

A residual plot was done on the vectors of the preliminary adjustment to determine if there were any outliers (Figure 3). The largest residuals were up to 9 cm on the vertical components and 12 cm horizontally.

Since the Kentucky HARN (1993) was adjusted prior to the existence of the CORS network, discontinuity in both the ellipsoid heights and positions was expected. Data from this survey (GPS1547) project provide us with the means to determine the level of this discontinuity, since these observations now tie the CORS stations to the HARN. NGS's policy is to correct discrepancies at the 5 cm level by readjustment of the HARN coordinates using these new data. The large residuals in the up components of the preliminary constrained adjustment indicate that the ellipsoid heights from the original HARN do not fit these data.

To determine how well the Continuously Operating Reference Stations (CORS) coordinates fit these data and to determine how the previously published HARN control was shifting in relation to the CORS, a constrained adjustment was run where only the CORS coordinates were held. A residual plot was done on the vectors of this adjustment to determine the outliers. Height discrepancies of up 4 cm shifts were identified in the up component at **PIKETON CORS ARP (PKTN)**. These discrepancies were further investigated but the problem could not be identified, therefore, NGS decided not to hold the ellipsoid height in the control of the adjustments. To get a good fit between the CORS and these data the horizontal adjustments will be analyzed without the published ellipsoid height of **PIKETON CORS ARP.** See Figure 4 for the residuals of the final CORS adjustment.

A second CORS adjustment was executed including the FBN ellipsoid heights from surrounding States. A comparison was made between the ellipsoid heights from this adjustment and those from the published A and B Order stations listed on Attachment 3. Differences of up to 9 cm were identified vertically at **CINDY AZ MK**. Horizontal coordinate comparison shifts were up to 9 cm at station **I75 T 52 RM 2**. See Attachments 3A and 3B.

The decision was made by NGS to constrain coordinates and ellipsoid heights of the CORS, including published A/B Order coordinates in Kentucky, Illinois, Virginia and West Virginia HARN projects in the final horizontal adjustment. All FBN determined ellipsoid heights from surrounding States were held, except the height for **PIKETON CORS ARP**, **CINDY AZ MK** and **MID** which are located in Virginia. The final ellipsoid heights of these stations will not be published. Ellipsoid heights from the Kentucky HARN projects were re-determined.

Coordinates for the following stations were re-determined because the differences between coordinates from this project and the data base were:

Station Name		Difference (m)	O/T	Source
I75 T 52 RM 2	(KY)	0.089	BA	GPS611/B
MT PLEASANT RESET	(KY)	0.051	BA	"
TARTER 2 RM 4	(KY)	0.049	BA	"

The variance of unit weight for the final constrained adjustment was 907.10 with 3111 degrees of freedom. The variance of unit weight ratio of the constrained adjustment to the free adjustment was 9.90.

Differences in meters between the re-determined ellipsoid heights from the final adjustment and the published heights from the original Kentucky HARN are listed on Attachment 4.

Differences in meters between the final coordinates from this project and the data base coordinates are listed on Attachment 5. Coordinates for three B order stations were re-determined and the differences are also listed on the above attachment. All A/B Order HARN and CORS coordinates were held and have a positional shift of 0.000. See Attachment 5B for the final horizontal adjustment constraints and Figure 5 for residual plot.

Vertical Adjustment

A free vertical adjustment was executed using one bench mark height as control to determine the elevation shifts in the project. Analysis of the free vertical shifts is listed on Attachment 6 and Figure 6.

The heights from this adjustment and the NGS bench marks were analyzed. Since these bench mark heights were consistent with the observations in the project NGS decided to constrain their elevations.

A final vertical adjustment was executed where all NGSIDB NAVD 88 bench mark elevations and several GPS orthometric elevations were constrained. GPS orthometric elevations were analyzed and held because they were consistent with the observations. Holding the GPS height for **CINDY AZ MK** did not affect the vertical adjustment. CORS elevation with "K" code was held. See Attachment 7 in the final.

The orthometric height with "K" code for **ASHEVILLE CORS ARP** was not held in the vertical adjustment because of 16 cm shift between the height determined in this adjustment and the NGSIDB height.

GPS heights for the following stations were re-determined. Most of these heights are from the Kentucky HARN project (GPS611):

Station	Difference (m)
7KA A	-0.10
BRUNER RESET	0.05
BULK	0.04
CANEY	0.06
GEOCEIVER STA 005 RESET	0.06
GLASPORT	0.06
GRATZ	-0.06
HABIT RM 1	-0.06
KY 03	0.08
KY 09	-0.06
LOUISVILLE S BASE RESET	0.05
MILLER	-0.11
PETERS RM 2	0.08
SAND GAP	0.08
STANPOINT	0.05
WOODBURN RM 1	0.05

A residual plot was done on the vectors in the final vertical adjustment. Several stations in the observations that are connected to the CORS had residual shifts up to 6 centimeters on the vertical components. Since these observations involved stations with ties to very long lines, inconsistencies are expected. Therefore, no rejections were made. See Figure 7 for the vertical plot.

The variance of unit weight for the final vertical adjustment was 107.84 with 2930 degrees of freedom. The final elevations in GPS1547 project are referenced to NAVD 88.

Free Adjustment with Accuracies

A final free adjustment was run to obtain accuracies over all lines. The final positions from the constrained adjustment were used as input. The variance of unit weight was 91.64 with 2814 degrees of freedom.

Approximately eighty percent (80%) of the A Order observed vectors exceeded the required standard (1:10,000,000). Most of the observed vectors that failed the requirement had very short distances. See the attached list of Length Relative Accuracies (Attachment 8).

Data Base Notes

Station **SEMONES** with SSN 0222 and PID=HY2565 was reset and had only descriptions. The new station name is **SEMONES RESET** submitted in this project.

Descriptions for the following stations were deleted from this project:

A 180	PID = GX2483
GLASPORT	GZ3039
FAA LOZ C	GZ3117
OWEN	HY2564
P 424	GA1159
U 410	HZ1967
VA 08	GA3696

Station **FAA CVG 0** submitted in this project is the same station as **CVG 0 FFA** located in the NGSIDB with PID=JZ3746. An investigation of these stations proved that they are the same station. The name for **CVG 0 FFA** should be changed to **FAA CVG 0** in the NGSIDB.